Project: **Wonder Factory**

Team 2-A

Primarily Report

Bader Alshammari

Mohammad Alsaidi

Shamlan Alshammari

Mohammad Alotaibi

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Instructor: **Sarah Oman**

Client: **The Alstons**

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Executive Summary

In this report, the project has presented about the Wonder Factory and crossword puzzle is the product developing for Wonder Factory. Wonder Factory is place for kids to get entertainment and education at the same through innovative ideas. Research has done on the design project and different existing designs have found. Along with customer requirements and engineering requirements have mentioned with HOQ. Then different design ideas have been presented as including the final design and from them, the final design has been selected by using the Pugh chart method and decision matrix method. Final design which selected is the Water throwing arrow which will hit the board and within 30 seconds' kid will find the word.

Table of Contents

1. Background

1.1 Introduction

Wonder Factory is an appropriate point for displaying interactive items related to children. Wonder Factory is currently present at Flagstaff and it provides the opportunity for children to amuse themselves by entertaining through different interactive displays. Wonder Factory has developed by Jackee and Steve Alston and their mission is to generate learning through play. They are passionate to bring next generation as thinkers, the makers, and the creators of the future. For this purpose, they have built Wonder Factory. In Wonder Factory, different unique and creative products put for displays, and these products are based on STEAM. STEAM stands for Science, Technology, Engineering, Art, and Mathematics. So, Wonder Factory is basically a space for children education with innovation.

In this course, we are working on the project which will place in Wonder Factory so this project will help our mentor and client in their vision and this project will be based on STEM and our client can present it to the children in Wonder Factory. This project will get place in Wonder Factory and will be an interactive display for the Wonder Factory and for the children as well. We are going to build Crossword Puzzle in this project. This project will play an important role for Education of children as it is Crossword Puzzle so this project will deal with the “Words” and this will increase the dictionary of children therefore it will be useful for children learning.

1.2 Project Description

We are building the project for Wonder Factory and the project must be unique, entertaining and educational as well. Our client want the project to display in Wonder Factory which will help children in their learning. With all these basic requirement, we have many options to choose from. For example,

- Crossword Puzzle
- MiniGolf
- Bicycle Electricity System
- Electric House

From these projects, we have decided to go with Crossword Puzzle because it is useful for learning. In Crossword Puzzle, alphabets will interchange their position and make new words. So crossword puzzle will help in good learning and will increase the dictionary of students. A

crossword puzzle will have a box inside with alphabets and these alphabets will be in some disorder form. There will be a word hidden in the disorder alphabets which will find by the children and that's the learning phase.

1.3 Original System

There is no system made before by the time when this project has started so this is a new and original system. The design of this system is original and there is no existing system for this project.

2 Requirements

Requirement for this are presenting in this section. These requirements have developed from details given for the project by the clients.

2.1 Customer Requirements (CRs)

Customer requirements are those requirements which client has provided directly to us and we should develop the project according to these customer requirements.

1. Safe to Operate
2. Child-like wonder
3. Tactile, Auditory, and Visual
4. Simple to Operate
5. Portable
6. Project Themselves into the role
7. Feel smart
8. Multiple visitors

2.1 Engineering Requirements

Engineering Requirements have built after understanding the client Requirements. Client stated that each design must be safe, so it must not have any sharp edge. It has decided that different designs should build for wonder factory so different ideas and their technical requirements have put into the Engineering Requirements

Table 1: Engineering Requirements

Engineering Requirements	**Targeted value**	**Tolerance**
Size	10x10 feet	2%
Weight	100 lb.	10%
Bulb Capacity	20 watt	5%
Safe, No Sharp Edge	-	-
Number of words	4	10%

Size

Size is the area of crossword puzzle, which must not be larger than 10 x 10 feet.

Weight

Weight of the product must be less than l00 lb. so it can easily carry and moveable as well.

Bulb Capacity

Bulb which will turn on when the correct answer will get must turn on and the energy of bulb will be 20 watts which will turn on using the battery power source.

Safe, No Sharp Edges

This is the important factor to consider as well because safety is important so the project must be safe to operate and must not have any sharp edge as well.

Number of Words

Number of words which will appear in the crossword puzzle must be less than or equal to 4 at maximum. It can be 1 word, 2 words, 3 words or 4 words but it cannot exceed this value.

2.3 Testing Procedures (TPs)

Testing procedures can be done easily to determine the requirements are achievable and correct or not. So, the procedure which can use to test each requirement is presenting below:

Size

Size of the project can determine by scale and measuring the length and width of the materials. So, size can test through scale

Weight

It can determine through the weight scale which determines the weight of any item. So, placing the project in the weight scale will tell its total weight so in this way weight of product can test.

Bulb Capacity

Capacity of output power obtained from the project can determine through the voltmeter equipment by placing positive knob with positive side and negative knob with negative side to

determine the output voltage and then calculating the output current. After that using the following formula

$$P = VI$$

Power of the system can determine and check if it is feasible or not.

Safe, No Sharp Edges

Sharp edges can determine by simply testing each edge whether the edge is sharp or not.

Number of Words

Counting the words and it will test whether it is obeying the engineering requirement target value or not for testing purpose.

2.4 House of Quality (HoQ)

HoQ is a chart that compares the connection between engineering requirements and customer requirements and give them a rate in terms of their connection to each other. By making the connection it will clear that which engineering requirement is most important to follow because from HoQ we will get the priority order. As customer requirements provides by the client whereas engineering requirements devised from customer requirements therefore engineering requirement need to link with the customer requirements

Engineering Requirements / Customer Requirements	Importance	Weight less then 100 lb	No Sharp Edge	Area less then 10 x 10 feet	Supply 20 Watt Power	Calculation for 10 values	less work for kids			Customer Competitive Assessment				
										1 Worst	2	3	4	5 Best
Safe to Operate	9	3	9	1	3		1							
Child Like Wonder	3	3	9		3	1	3							○
Tactile, Auditory and Visual	3	1	1		1	3	3					▲	□	
Simple to Operate	9	9	3	3	3	3	1				□			□
Portable	9	9	3	9		1	3			○		□		○
Project themselves into the role	1		1				1					▲	○	○
Feel Smart	1			3		9	1							
Multiple Visitors can attend	3	1		9	3	1	3							

Technical Importance: Raw Score	204	166	147	75	60			
Technical Importance: Relative Weight	**31.3%**	**25.5%**	**22.5%**	**11.5%**	**9.2%**			
Techanical Target Value	10	-	9	50	4			
Upper Target Limit								
Lower Target Limit								
Units	lb	-	Sq. ft	Watt	-			

Figure 1: HoQ

3 Existing Designs

Chapter 3 talks about the research methodology for looking about the project. It is important to know that if you can find some of the similar designs related to your project because these will help you in making the project. Therefore, it is important to find the existing designs.

3.1 Design Research

Design research is basically the methodology to find the data that relates to the project and our final design to ensure that the correct design was chosen for this project. Our project is to make the crossword puzzle game therefore we have look around on internet and try to find the related products and the different explanations about the learning from crossword puzzle and different ways through which crossword puzzle can play [1]. Crossword puzzle can play in different ways like

1. Fill the empty boxes by the help of clue to make the meaningful word [1].
2. Select the alphabets one by one to make a meaningful word [1].
3. Find the meaningful word from the disorder form of alphabets [1].

From the design research, we have found that we can develop crossword puzzle with any of the above type. Before that we were only aware of the crossword puzzle in which words will find from the disorder alphabets. Next move towards the system level of our design.

3.2 System level

After the research has done, few existing designs have found which are closer to our project. These designs will help us in building our project. These designs are presented below.

3.2.1 Existing Design # 1: Butterfly Puzzle

This design consists of a butterfly with boxes in it. Concept of paly is to make the meaningful words in it. As the puzzle is showing below.

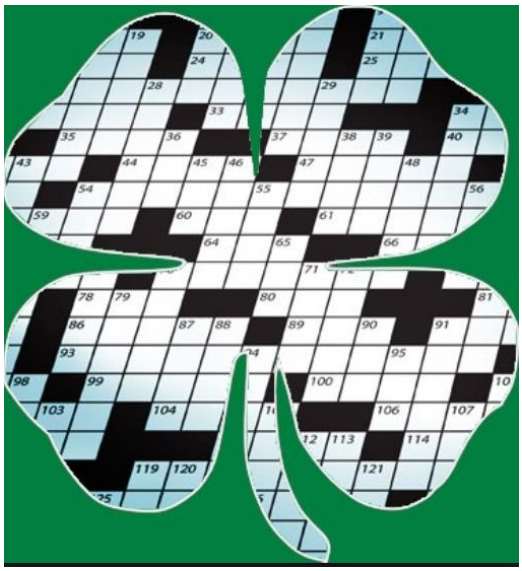

Figure 1: Butterfly Puzzle [2]

3.2.2 Existing Design # 2: Stairs Design

In this design, the idea is to join different cut boards and make the words in meaningful way. All the cut boards are in connector form so they can interconnect with each other in easy way. Design is showing below as

Figure 2: Stairs Design [3]

3.2.3 Existing Design # 3: Giant Puzzle

In this game, a giant puzzle has formed on the paper chart and with the cutting paper box on which alphabets have written, uses for making the meaningful words. As showing below

Figure 3: Giant Puzzle [4]

3.3 Functional Decomposition

It is a way decompose the project into smaller parts and identify the working of project. In this way, it becomes easy to understand the inputs, outputs and inside functionality of any project. Therefore, two of the model have developed for this project, one is black box model and second is hypothesized model, and both are presenting below.

3.3.1 Black Box Model

This model basically tells the system information which is only limited to the inputs and outputs of the system and these inputs and outputs are consisted to three things. They are materials, energies, and signals. Black Box model of this system is showing below as follow

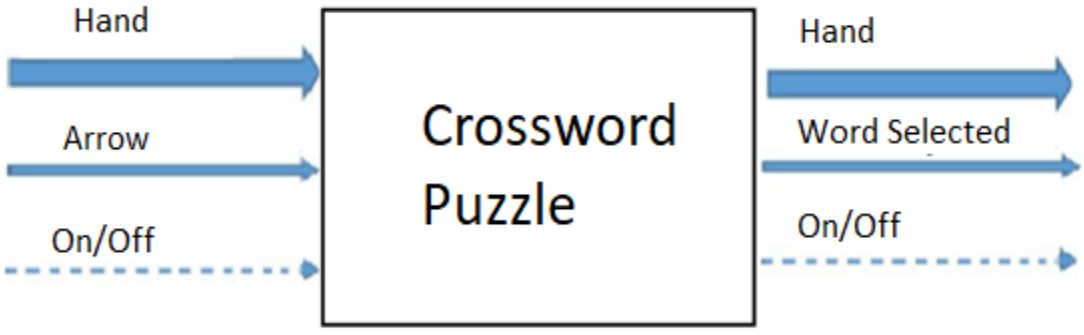

Figure 4: Black Box Model

3.3.2 Functional Hypothesized Model

Hypothesize model explains the internal working of the project. All the working which will be done in the system will explain this model as the model is presenting down.

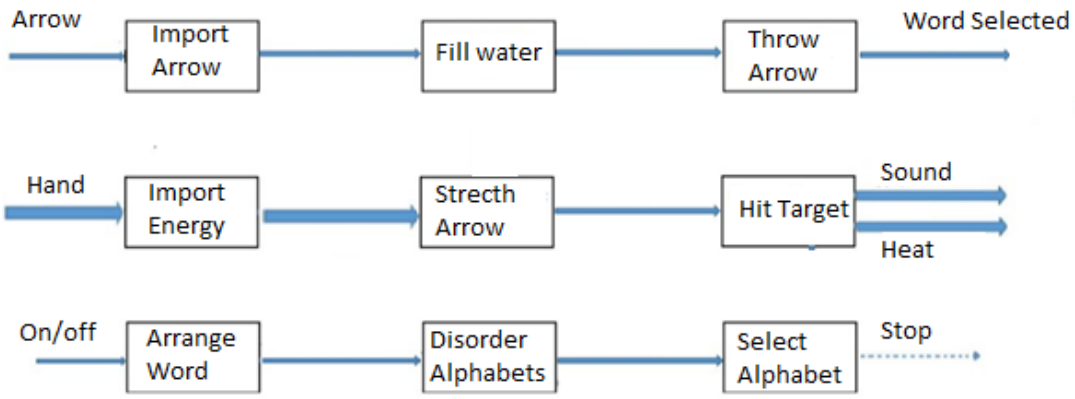

Figure 5: Hypothesized Model

3.4 Subsystem Level

Sub-system level is about the parts of project and their existing design. In this section, we will discuss our three-sub system for the project.

3.4.1 Subsystem # 1: Arrow

Arrow is a sub-system which will use to select the word, as there are multiple types of arrows have already available in the market so this part is about the existing designs which have made for the arrows.

3.4.1.1 Existing Design # 1: Plastic Arrows

Plastic arrows are easily available and light weight. These type of arrows can use for slow hitting and without hurting anything. Therefore this existing design is useful for our project and we can use the plastic arrow for crossword puzzle. Plastic arrow is showing below

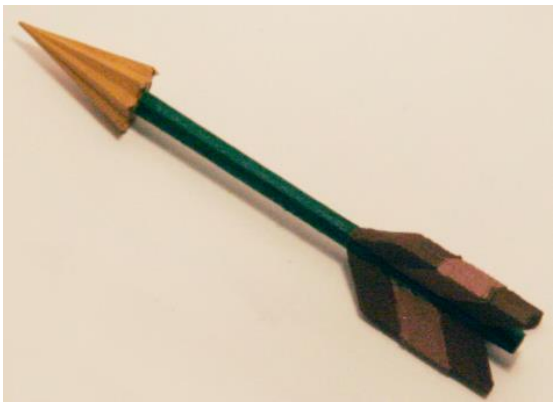

Figure 6: Plastic Arrow [5]

3.4.1.2 Existing Design # 2: Steel Arrow

Steel arrow are also available for use. These type of arrows are hard and tough and these arrows can use for hard hitting and indicating anything. These type of arrows can use in our project but these are not safe as it can hit any children and it will hurt the children. Steel arrow is showing below

Figure 7: Steel Arrow [6]

3.4.1.3 Existing Design # 3: Wooden Arrow

Wooden arrow already made so this type of arrow is useful as it is less hurting and hard as well to indicate any item. In this project the arrow will use to hit the word and the mark must be present on the icon of alphabet to recognizing which alphabet box has hit by the children therefore this is also useful for our project as it is showing below.

Figure 8: Wooden Arrow [7]

3.4.2 Subsystem # 2: Board

Another subsystem of our project is the board on which the alphabets will hold and this is the base of our project. There are multiple of boards which can use for this project. And some of the existing designs the board are presenting in this section.

3.4.2.1 Existing Design # 1: Wooden Board

Wooden boar is the good option to use for this project because it is safe to use and it will be hard and strong as well when the arrow will hit the alphabet it will not breakdown as showing in the following figure

Figure 9: Wooden Board [8]

3.4.2.2 Existing Design # 2: Plastic Board

Plastic board can also use for the base, and inside the board alphabets can place as well. it is light weight therefore it is useful for our project as showing in the figure.

Figure 10: Plastic Board [9]

3.4.2.3 Existing Design # 3: Steel Board

Steel board can use for our project but it is hard and holding item on the board is difficult. The existing design for the steel board is showing below

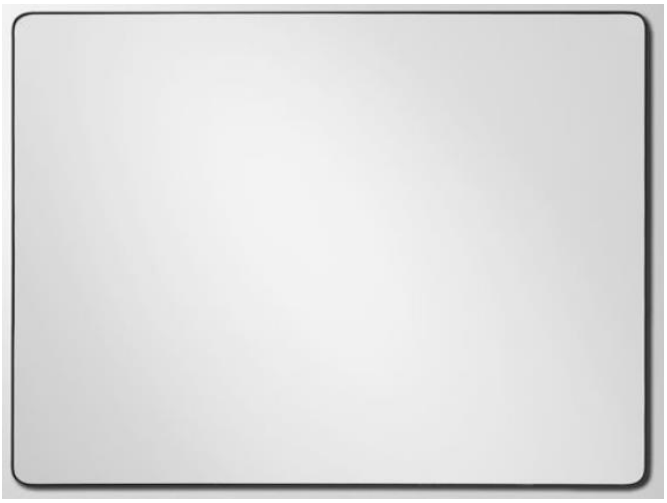

Figure 11: Steel Board [10]

3.4.3 Subsystem # 3: Alphabets Icons

One of the major part of our project is the icons of alphabets which will display on the board and the children will hit those icons throw the arrow. There are different existing designs for making the alphabets icons.

3.4.3.1 Existing Design # 1: Paper icons

Paper can use for making the icons and then the icon will display on the board with the help of gum. As the basic purpose is to make the big icon which easily hit from the arrow so making the icon with paper will easy and these can replace any time as well, as showing below.

Figure 12: Paper icons [11]

3.4.3.2 Existing Design # 2: Cardboard icons

Cardboard can use for making the icons and these icons are strong and have long life comparing to the paper icons. These could be used in our project as we need them to fit in the box. An example of the cardboard icon is showing below

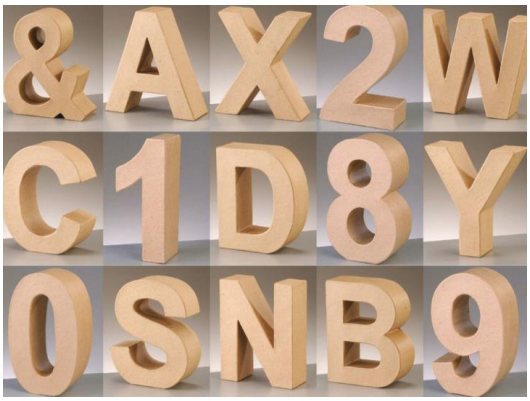

Figure 13: Cardboard icons [12]

3.4.3.3 Existing Design # 2: Plastic Icons

Plastic can also use for the icons and this existing design is useful for our project as well.

Figure 14: Plastic Icons [13]

4 Designs Considered

For making any project it is important to consider multiple design options and then finalize one of the design which is perfect and fulfill all the requirements of clients. In this part, different designs which have considered for making this project will present.

4.1 Design # 1: Ball hitting Board

In this design the idea is to hit the ball on the icon and in this kid will find the alphabet. Concept is that the kid will hit ball one by one to each alphabet and find the complete meaning full word. The idea is showing as

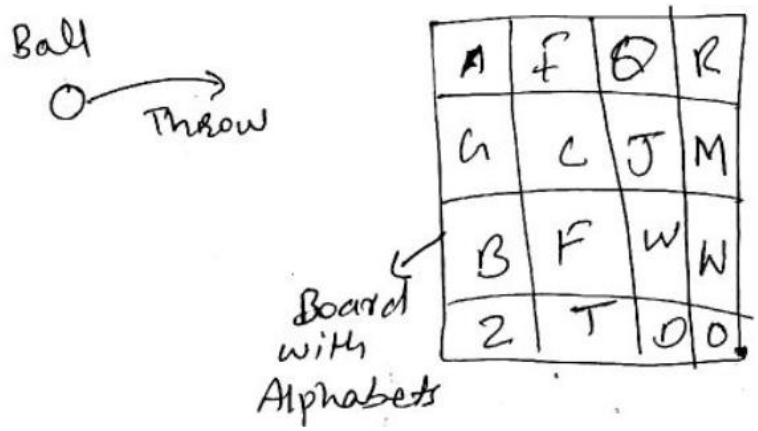

Figure 15: Ball hitting Board

Advantages

- Edges are blend
- Easy to play
- Ball can bounce back
- Safe for children
- Easy to Set-up

Disadvantages

- Time consuming
- Difficult to identify impact of ball.

4.2 Design # 2: Board on ground

The idea is to place the board on the ground and the kid will throw the arrow in the air which will drop on the board and in this way kid will find the word. As the idea is showing below.

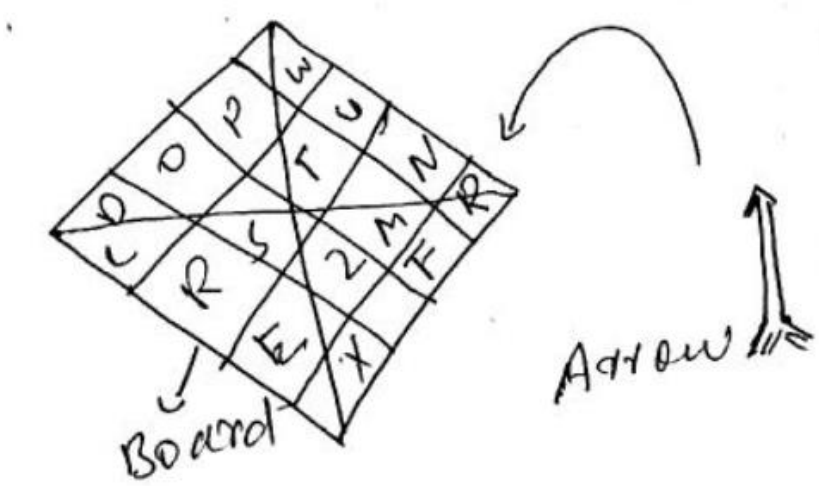

Figure 16: Board on ground

Advantages

- Moveable
- Safe and no sharp edge
- Portable
- Easy to set up

Disadvantages

- Difficult to play
- Difficult to keep placing it on the ground.

4.3 Design # 3: Water arrow to hit board

Idea behind this is design is that a kid will fill the arrow with water and the board will place in front of it. Then the kid will throw the arrow toward the board and kid will identify one word, now fill the arrow again and judge the next word. The water will tell which alphabet has hit and is it correct or not. The game is to play this task in 30 seconds and then see if the kid make it or not. The idea is showing in the figure.

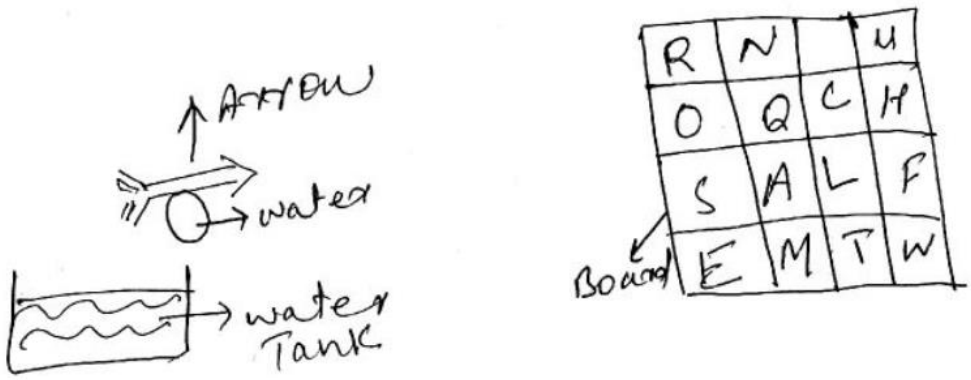

Figure 17: Water hitting arrow

Advantages

- Moveable
- Easy to use
- Moveable

Disadvantages

- Time taking

4.4 Design # 4: Rotating Wheel

The idea is to make the rotating wheel which will rotate and then the kid will stop the wheel and the alphabet in front of arrow head will be the one which has selected and repeat this step until the complete word has found.

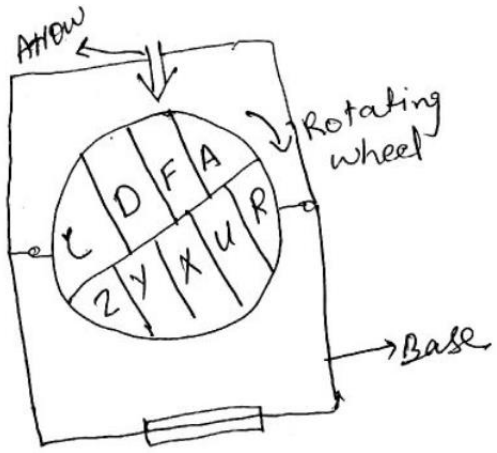

Figure 18: Rotating Wheel

Advantages

- Easy to use
- Portable

Disadvantages

- Difficult to run the wheel by kid

4.5 Design # 5: Stairs board

The idea is that kid will stop the ball on the row in which correct alphabet is present and then it will take that alphabet and put it down in the lowest free area to make the complete word, as showing below in the figure.

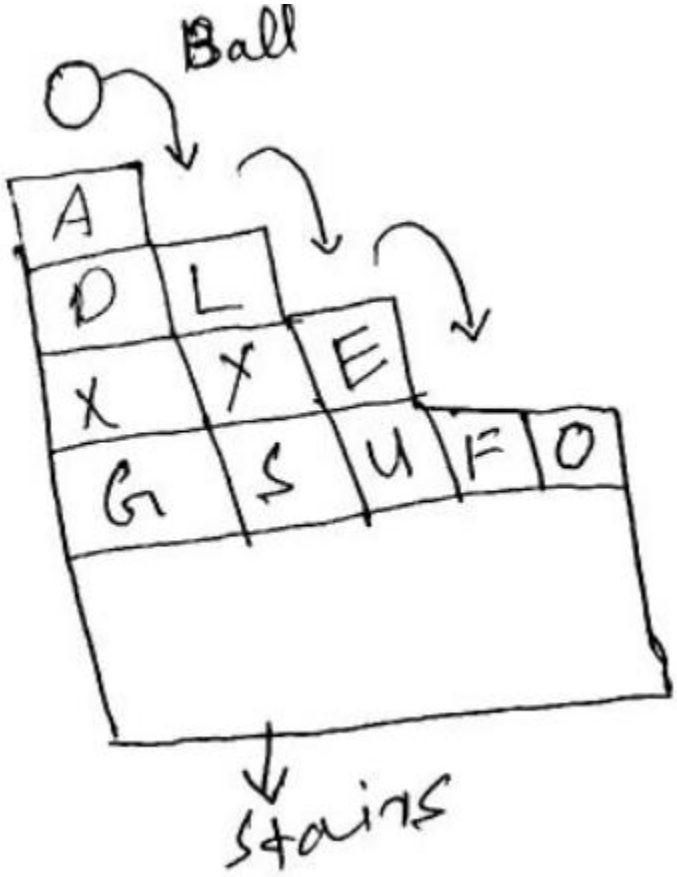

Figure 19: Stairs board

Advantages

- Moveable
- Easy to use

Disadvantages

- Cannot handle the correctly

4.6 Design # 6: Rotating Flower

This design is about the flower, which is in rotating form and the kid will hit the flower with correct point to find the alphabet. As it is showing below.

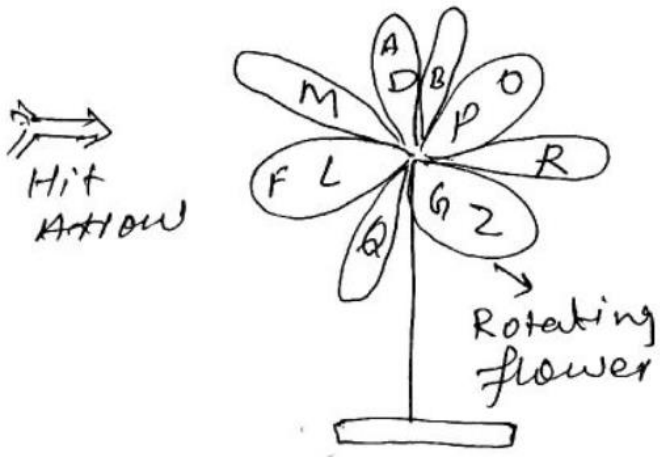

Figure 20: Rotating Flower

Advantages

- Easy to use
- Portable
- Entertaining

Disadvantages

- Difficult to find the correct word while the flower is rotating.

4.7 Design # 7: Box Puzzle

In this design the concept is that a box with enclosed alphabets which can read from the closed box, kid will tell the correct word and the box will open else it will not open. The design is showing below in the figure.

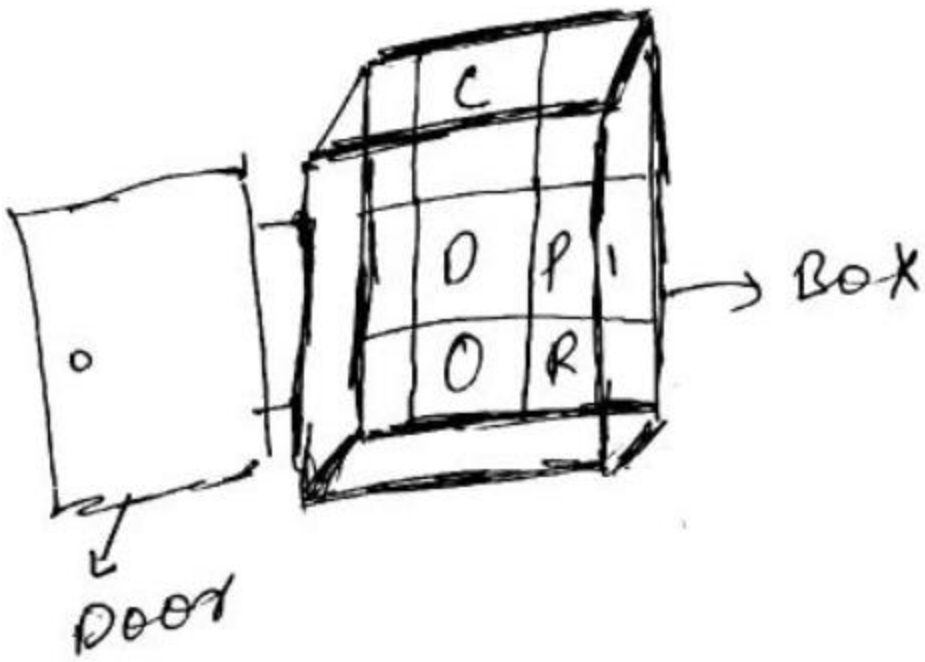

Figure 21: Push Wall with Baby Walker

Advantages

- Easy to use
- Entertaining
- Sound motivations
- Portable

Disadvantages

- Control for the kid is not possible

4.8 Design # 8: Mobile Board

The idea is to make the mobile board which will have the keypad and kid will enter the correct word, one by one alphabet and it will determine the correct word until then it will keep telling the kid you are entering wrong. The idea is showing in the following figure.

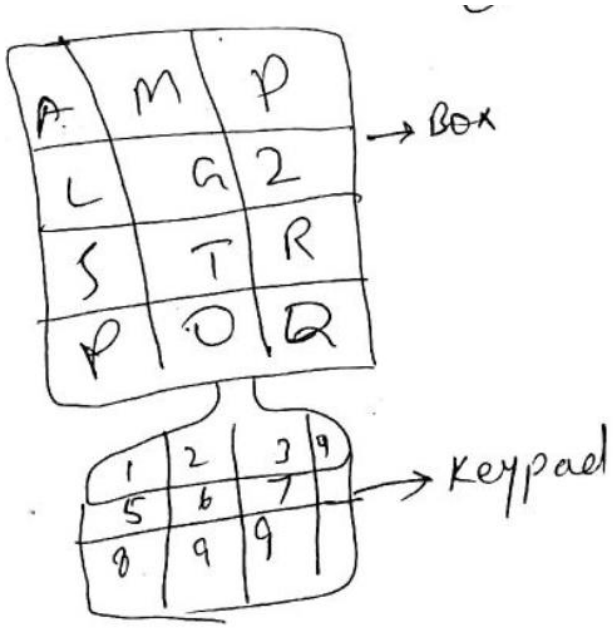

Figure 22: Mobile board

Advantages

- Easy to use

Disadvantages

- Difficult to handle by the kid.

4.9 Design # 9: LED based Puzzle

The idea is that a ball will throw to each alphabet and the LED will show green light if the correct alphabet has hit, in this way kid will keep hit the board with ball and find the correct word as the figure is displaying the idea.

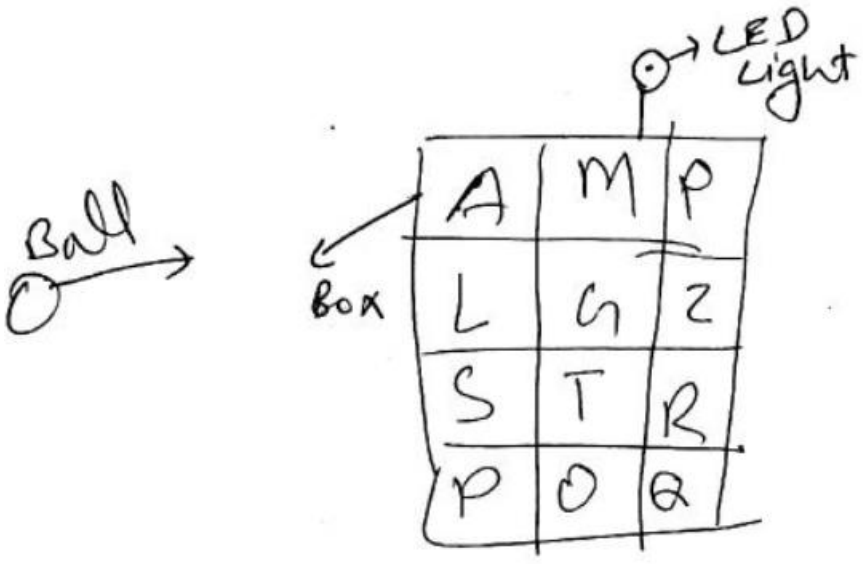

Figure 23: LED based Puzzle

Advantages

- Easy to use

Disadvantages

- Controlling LED is difficult

4.10 Design # 10: Dropping Cards

The idea is that children will drop each alphabet by hand which is wrong, so the correct one will keep remain in the board and the correct word will determine as showing below

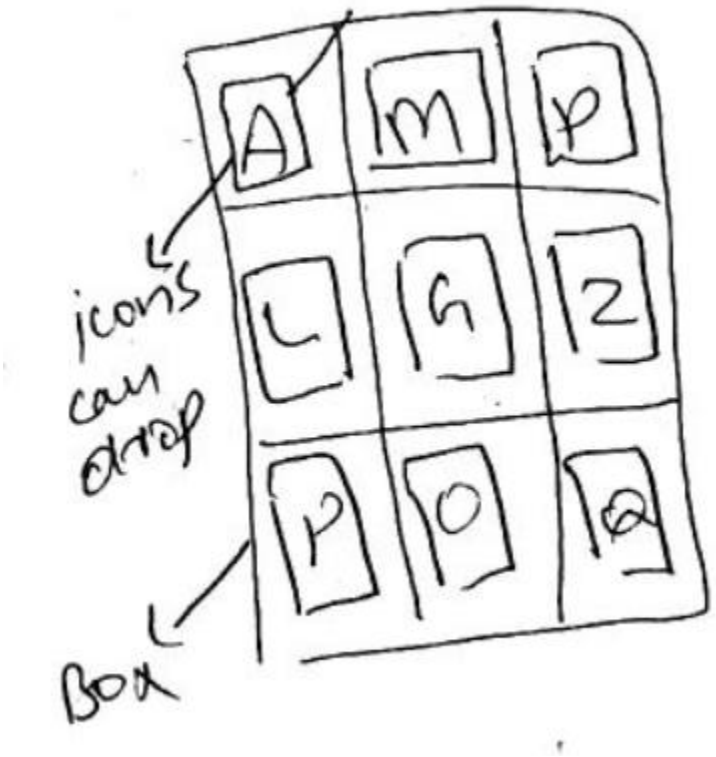

Figure 24: Dropping Cards

Advantages

- Easy to use

Disadvantages

- Not safe
- Any card can hit the children

5 Design Selected

This chapter is about the selection criteria and explaining different ways to select the final design. There are different methods available through which the final design can select. And these methods, Pugh chart, decision matrix etc. So in this section same methods are going to use for finding the final design.

5.1 Rationale for Design Selection

In this project we are going to implement the crossword puzzle, in which the design idea is to make such a crossword puzzle which is entertaining, safe and educational for children. Therefore 10 design ideas have generated and from those ideas now we need to narrow down and find the final design. Therefore Pugh Chart is using which will narrow down the result to final three designs and then those three designs will use in decision matrix to finalize the design. In Pugh chart all the customer requirements will test for each design and see which are customer requirements are present in the design and which are not. In this way all those designs which have customer requirements will get positive marks and then summing all the marks to find the top three final designs from the Pugh chart. Pugh chart is showing below:

Table 1: Pugh Chart

5 Designs for Fun Apparatus	Weightage	Ball Hitting Board	Board on Ground	Water arrow to hit	Datum Design: Rotating Wheel	Rotating Wheel	Stairs Board	Rotating Flower	Box Puzzle	Mobile Board	LED based Puzzle	Dropping Cards
Safe to Operate	7	+	-	+	D	+	+	-	-	+	+	-
Child-like wonder	6	S	-	+	D	-	-	S	+	+	+	+
Tactile, Auditory and Visual	5	-	-	+	D	+	-	-	S	+	-	-
Portable	4	+	-	+	D	+	+	S	-	-	-	S
Project themselves into the role	3	-	-	+	D	S	+	+	-	-	S	S
Feel Smart	2	+	+	+	D	-	-	-	S	S	-	+

Multiple Visitors	1	-	+	+	D	+	-	-	-	S	S	-
Pluses		3	2	7	-	4	3	1	1	3	2	2
Minus		3	5	0	-	2	4	4	4	2	3	3

From the Pugh chart we can see that there are three designs which are at the top, number one is "Water arrow to hit" and second is "Rotating Wheel" and the last one is "Mobile Board". These designs have found as the top three because these three are fulfilling most of the customer requirements. As we see the top 1 which is fulfilling all the requirements so it could be count as the final design but it is better to go with the second method and take the three top designs and narrow down the result to final design using the decision matrix. In decision matrix, each requirement will check with each design and marks will give to each design for each requirement which multiple with its weightage value and then sum up all the values to make the total score. This will be done for each design and then check which has got the highest marks and that design will be final design.

Table 3: Decision Matrix

	Safe to Operate	**Child-like wonder**	**Tactile, Auditory and Visual**	**Portable**	**Project themselves into the role**	**Feel Smart**	**Multiple Visitors**	**Total**
Weightage	7	6	5	4	3	2	1	
Water arrow to hit	5x7=35	6x6=36	2x5=10	7x4=28	7x3=21	5x2=10	5x1=5	145
Rotating Wheel	4x7=28	5x6=30	3x5=15	1x4=4	2x3=6	4x2=8	2x1=2	93

Mobile Board	3x7=21	2x6=12	1x5=5	2x4=8	2x3=6	2x2=4	4x1=2	58

Table 1.3: Decision Matrix

Decision matrix gave us the final design as the highest marks value is the “Water arrow hit” design because it is fulfilling all the customer requirements, not even a single requirement is missing from this design. It is easy to use, it is safe to operate, it is tactile, entertaining, and child-like wonder is present as well in this design that is why “Water Arrow Hit” has selected our final design.

References

[1] W. Merriam, “Crossword Puzzle”, available [online], https://www.merriam-webster.com/dictionary/crossword%20puzzle

[2] Pintrest, “Butterfly Puzzle”, available [online], https://www.pinterest.com/mothermeri/puzzle-ideas/?autologin=true

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